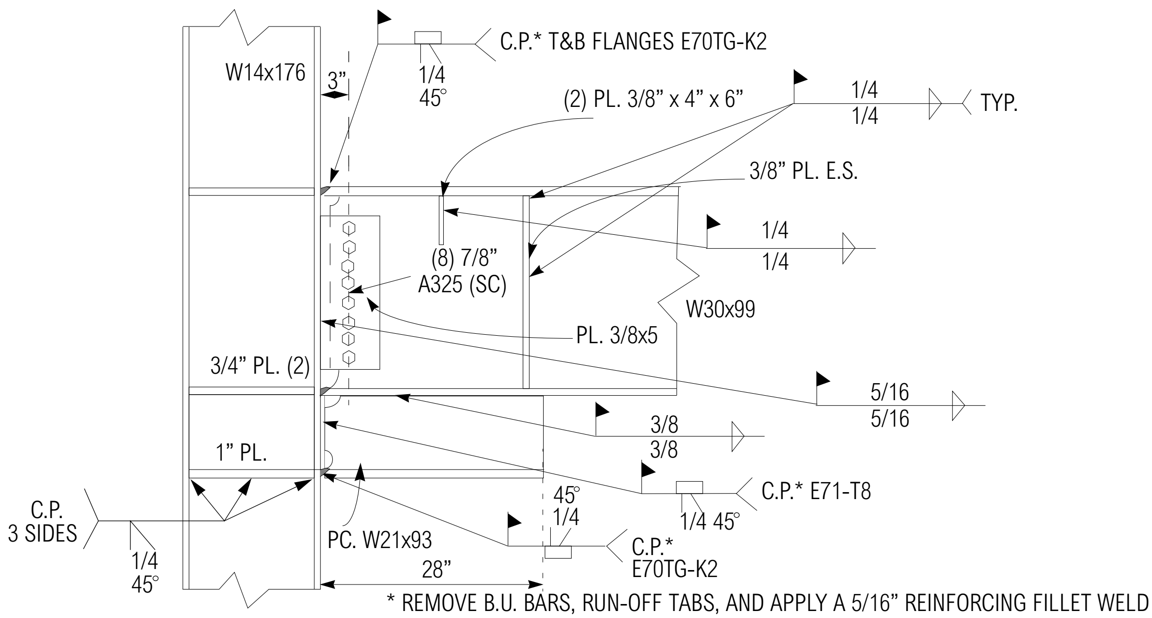
SAC Steel Project

Test Summary No. 28

the FEMA Program to Reduce the Earthquake Hazards of Steel Moment Frame Structures

Specimen ID:	UCSD-6
Keywords:	New construction, straight haunch, vertical stiffeners, notch-tough electrode, haunch separation, local buckling, top flange fracture, medium rotation capacity
Test Location:	University of California, San Diego
Test Date:	September 19, 1995
Principal Investigator:	Chia-Ming Uang; with Duane Bondad
Related Summaries:	None
Reference:	"Experimental Investigations of Beam-Column Subassemblages", *Report No. SAC 96-01*, March 1996.
Funding Source:	FEMA / SAC Joint Venture, Phase I

CONNECTION DETAIL



MATERIAL PROPERTIES AND SPECIMEN DETAILS

Member	Size	Grade	Yield Stress (ksi)		Ultimate Strength (ksi)	
			mill certs.	coupon tests *	mill certs.	coupon tests *
Beam	W30X99	A36	49.3	46.5 flange 57.1 web	71.8	67.7 flange 72.5 web
Column	W14X176	A572 Gr. 50	55.0	52.5 flange 51.2 web	74.5	68.2 flange 67.2 web
Haunch	W21x93	A572 Gr. 50	N.A.	51.2 flange 54.0 web	N.A.	67.8 flange 69.2 web
Web vertical Stiffeners	1/2” plate	A36	N.A.	45.2	N.A.	66.9

Welding Procedure Specification	Horizontal CJP groove weld: FCAW-SS, 3/32” diameter AWS E70TG-K2 electrode; all welding to be in accordance with AWS D1.1 Vertical CJP groove weld and fillets: FCAW-SS, 0.72” diameter AWS E71-T8 electrode; all welding to be in accordance with AWS D1.1
Shear tab	3/8”x 5” plate with eight 7/8” A325 (SC) bolts; no supplemental welds
Panel zone	No doubler plates
Continuity plates	3/4” plates with c.p. weld, 1” plate at the haunch level with c.p. weld
Boundary conditions	Single-sided test, no floor slab, axial load in lower half of column equal to beam shear, specimen tested in upright position
Other detailing	Add vertical stiffeners on each side, remove B.U. bars, add reinforcing fillet weld

N.A. = not available

*Coupon locations per ASTM

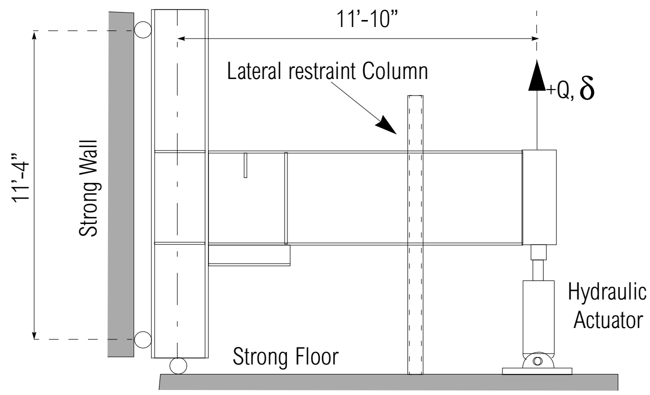
BACKGROUND

Specimen was tested to evaluate new construction approaches. The size of the beam and column were identical to the other specimens tested at UCSD. The improved performance of the specimen with a triangular haunch (Test Summary No. 19) motivated the design of a specimen with a straight haunch, potentially reducing labor requirements.

The beam flanges were welded to the column flange using full-penetration groove welds. Notch-tough weld metal (AWS E70TG-K2) was used for the horizontal groove welds. The same welding material was used to weld the haunch flange to the column flange, and AWS E71-T8 wire was used to weld the haunch web to the column flange. For all these welds, backup bars were removed and 5/16” fillet reinforcing welds were applied. To avoid local buckling of the beam top flange, full-height beam web stiffeners were used at the free end of the haunch. Because the distance between the stiffeners and the column face was larger than the observed buckling length in previous tests (Test Summaries No. 17 and 19), a pair of short stiffeners were added at the mid-length of the panel with the intent of moving top flange local buckling outside the panel. An additional 1 in. thick continuity plate was also added at the haunch level. The shear tab was welded to the column flange, and bolted to the beam web.

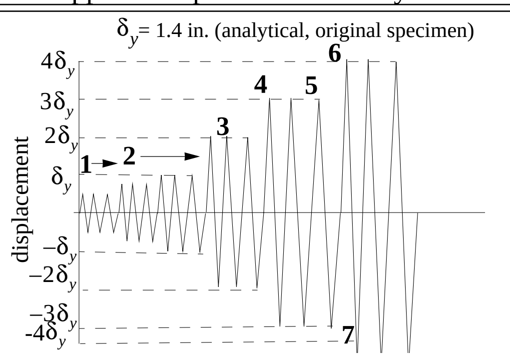
The standard SAC/ATC-24 loading history was used in the testing of the new specimen. The cyclic tests were performed quasi-statically. The value of yield displacement (δ_y) was assumed to be 1.40 in. to provide consistency with the previous tests.

TEST SET-UP



DISPLACEMENT HISTORY AND KEY EXPERIMENTAL OBSERVATIONS

Applied Displacement History



Key Observations of the Test

Point	Description
1	Local yielding at the free end of the haunch
2	Local yielding at the fixed end of the haunch
3	Fracture of the fillet weld at the haunch end, haunch separation of 5.5 in.
4	Local buckling of the beam top flange near column
5	Complete separation of the haunch from beam; local buckling of beam bottom flange near column face
6	Severe local buckling near the column of the beam top flange
7	Complete fracture of the beam top flange adjacent to the column

DETAILED TEST RESULTS

Quantity (see Introduction for definitions used in UCSD tests)		Maxima
Force/Displacement Properties	Peak actuator force (kips):	~150
	Beam tip displacement (in.):	3.7
	Experimental yield displacement (in.)	1.53
Rotation Capacity	Maximum plastic rotation (% radian):	3.5 (one half-cycle)
	Cumulative plastic rotation (% radian):	40.6
Energy Dissipation Properties	Cumulative energy dissipated (k-in.):	5873

Mode of failure: Fracture of the beam top flange adjacent to the column during the first negative $4\delta_y$ cycle.

DISCUSSION

At the free end of the haunch, local yielding, due to stress concentration, was observed during the displacement cycles to $0.5\delta_y$. During the excursions to $0.75\delta_y$, local yielding at the fixed end of the haunch began to radiate from the top web access hole. This pattern continued during the excursions to $1\delta_y$. During the $2\delta_y$ cycles, yielding in the haunch web and upper panel zone continued to spread, and yielding in the lower panel zone was also observed. During the second positive excursion, the fillet weld at the end of the haunch fractured over a length of 5.5", due to the large stress concentration. During the first positive excursion of $3\delta_y$, local buckling of beam top flange next to the column was noted; the addition of the short stiffener did not prevent the local buckling from occurring near the column face. During the third positive excursion, the haunch completely separated from the bottom flange, leaving the specimen similar in geometry to a pre-Northridge specimen. Thus, the local buckling of the beam bottom flange radiated from outside the haunch to near the column face. The top flange experienced severe local buckling during the first positive excursion to $4\delta_y$, and the flange fractured during the following negative excursion. The maximum plastic rotation of the connection was approximately 3.5% radian. The repair scheme did not significantly improve the performance of the connection due to the detrimental effects of the stress concentration at the end of the haunch. To further improve the response of the connection, it is suggested either a sloped end to the haunch be provided, or vertical haunch stiffeners near the end of the haunch be provided on each side.